methods and their associated theoretical interpretation the precise yield of a very large device. But that it would be very large and that it would work, we would know is extremely important.

The margin of error in predicting underground yields is only slightly greater than the margin of forecasting atmospheric yields. But in sound scientific opinion, when high-yield weapons are being developed—if we should choose to do so—this margin of error in terms of megatons has little strategic significance.

With respect to whether the Russians have gained an advantage in yield-to-weight ratios from their high-megaton tests in the atmosphere, and whether the treaty would prevent us from obtaining a better ratio, it should be remembered that the weight of the system depends to a large extent on the weight of the total mechanical system—including the case and the electronic components. Improvements of these elements can be accomplished without a nuclear detonation. Moreover, new nuclear materials can be tested underground and findings scaled up for larger yields.

To return to the Manhattan Project of World War II, our scientists were able to develop nuclear devices without previous experience to build on, and those primitive devices worked—as the scientists said they would.

They have ingeniously contrived all kinds of solutions to difficult problems, and I am sure that one must agree with Dr. Bradbury that if underground testing is all that is to be available, the scientists will learn to use this medium even more effectively and will gather data much beyond what has been done to date. John Foster, Director of the Lawrence Radiation Laboratory, at Livermore, who opposes the treaty, agrees with this view.

It has been said that the cost of underground tests is greater than for atmospheric tests. If the costs are calculated on the basis of the scientific device and the preparation of an underground site compared with the cost of an airplane or tower or rocket, the underground costs are far more. But, in fact, the atmospheric tests frequently have involved large task forces. In one series in the Pacific, in the neighborhood of 19,000 men were involved. The cost of that task force was upward of $100 million. And that does not include substantial funds for preparation of the site as well as the work after the actual series was completed.

Indeed, if total costs are compared, without question, underground testing is far cheaper.

There is a positive bonus gain in underground tests as to improvement of methods of detecting such shots. We will be able to advance our knowledge and capability to detect underground detonations by other countries because we will be accelerating and refining our own experiments in this environment. Since the Soviet Union no doubt will be conducting more underground detonations, this will provide an excellent operational test of our detection systems.

General Power has referred to the ultimate question of weapons systems, and that is the number that will "survive and arrive." I agree.

Are th Russians afraid of the hundreds and hundreds of bombs in our stockpile? No. They are afraid of American bombs that can be put over their heads. What carries our bombs there? It is a vehicle of some sort. It is the components that guide the vehicles which are critical. Unless the warhead gets there, there is no sense in worrying about the warhead.

I think it can be said that the nuclear warhead, including the fusing and firing circuitries which have been a rather difficult problem since the beginning of the program, has a higher reliability factor than the vehicle which carries it. It might be said that a nuclear system might fail to get to its destination infinitely more often than a nuclear warhead may fail to detonate over its target.

One can agree at this point that every warhead that gets to its target should have a certain detonation because it may be one of the few systems that gets through the enemy's defenses and offsets the carrying system's lack of reliability. I think one must accept this as a valid premise. However, the defense against the charge of having an overkill capability in the point that because there is a doubt as to the number of systems that might survive either the initial enemy attack or succeed in penetrating the enemy's defense, a great variety of weapon carriers are needed and a great number of bases from which strikes can be made either on land or, in the case of the Polaris, by submarines are required.

The military philosophy of multiple weaponry is the correct one and it is not based solely on system reliability.

I turn to the defense against ballistic missiles, where many grave doubts are expressed regarding the treaty. This exchange took place in the Foreign Relations Committee between the Senator from Nebraska [Mr. CURTIS] and the Chairman of the Joint Chiefs of Staff:

Senator CURTIS. Now, if there is much to be learned, and it depends on what research turns up in the future, what causes you to believe that nowhere in the future of the development of an antiballistic missile will atmospheric testing be essential or important?

General TAYLOR. Primarily because the problems in the antiballistic missile field, which are numerous and which are difficult, lie not in the warhead, not in the atomic component, but in the guidance, the radar, all of the associated equipment which goes with an accurate intercept of an incoming object moving at great speed.

In these areas indeed there is a great deal of work still to be done. But insofar as being sure that we have an atomic warhead that will go off at the right time, that is relatively easily solved. So I would stress the fact in the atomic aspects of the program we do not find the principal difficulty.

I will not go into the complexities of deploying an adequate anti-ICBM system. These are familiar to Senators; I cite General Taylor's statement because it establishes that the problem is not in the nuclear part of the system.

But I have these comments. With reference to the vulnerability of our silos in terms of enemy strike, one must assume that certain assumptions were made in the structural design of the hardened base. Without getting into classified information, it would seem that no manmade missile silo which has been designed for a quick response and must remain always in a state of readiness could be 100 percent protected from a direct hit.

If a silo were buried 3,000 feet under the ground, it would be very doubtful if its missile could be launched against the enemy in anything like the 10 or 20 minutes which is highly desirable in order to avoid it being caught by the next wave.

Even with the best antiballistic missile defense, in any nuclear war a number of enemy ICBM's will penetrate and strike this country. Because of the destructive power of these weapons, we can grimly expect large numbers of casualties. Ultimately, the most effective antimissile system is that which deters an attack. The tremendous power of our nuclear weapons and our capability to put substantial numbers of them onto an attacker's homeland is what deters that attacker. We can improve this deterrent capability without nuclear tests in the atmosphere. As Dr. Brown testified before the Foreign Relations Committee:

U.S. penetration aids now under development will be effective against much more sophisticated systems.

In other words, with or without U.S. nuclear tests, the U.S. penetration aid capability gives us confidence that our missile systems will penetrate presently designed ABM systems with a large margin of safety. Development and massive defensive deployment of a more advanced system would take a number of years, either for us or for the Soviets, if by the Soviets, that would give us enough time to develop more advanced penetration aids and deploy more missiles of our own.

Mr. President, it has been said that we have great gaps of knowledge about the effects of nuclear weapons on our underground sites.

But, Dr. Herbert York, Director of Defense Research and Engineering during President Eisenhower's administration, testified:

Some concern has been expressed about the fact that our knowledge of the vulnerability of Minuteman missile sites is incomplete and that the treaty will prevent us from developing that knowledge further.

We need to remember in this connection that we undoubtedly know a great deal more about the vulnerability of our sites than the Soviets do, since we alone are well informed on the nature and structure of the silos and have performed a number of test explosions relevant to them.

A good deal has been said about the possible effects of atomic blasts on communications, the so-called blackout phenomena. Let us examine the problem. Our scientists are not babes in the woods in this area. American atmospheric tests in the South Atlantic and Pacific first revealed that communications could be disrupted by certain types of nuclear explosions in the atmosphere.

Mr. President, I was surprised to hear so many people refer to the need for the development of an antiballistic missile system and the fact that we have not conducted high-yield tests. Therefore, I want to emphasize for the RECORD on this

point something which has been carefully prepared.

HIGH ALTITUDE TESTS

The United States has conducted many more high altitude explosions than has the Soviet Union. In 1958, prior to commencement of the so-called moratorium, the United States conducted five high altitude nuclear weapons effects tests. Since the resumption of testing by the Soviets on September 1, 1961, the Soviets conducted about four high altitude tests, but the United States in 1962 conducted five high altitude tests above the Pacific Ocean.

Let us recapitulate these U.S. tests.

Three tests were conducted high above the South Atlantic; these were the Argus tests. This was purely for effects purposes. It was an experiment designed to provide information on the traping of electrically charged particles in the earth's magnetic field. This information is important to the understanding of the phenomena associated with communications blackout and defense against ballistic missiles. The detonation altitudes were all about 300 miles above the surface of the earth. These were low yield kiloton tests.

In August 1958 and prior to the Argus events, megaton range shots, two in number, were conducted at high altitude above the Pacific Ocean, near Johnston Island. The Teak shot was at about 50 miles and the Orange shot was at 27 miles. These events were used for the study of effects relating to communications and radar blackout. These effects on the communications spectrum were studied intensively and were studied from different locations, close in as well as worldwide.

In 1962 we conducted five high altitude events above the Pacific near Johnston Island. Four of these were of low to submegaton yields, detonated at altitudes of tens of kilometers, and the most famous, Starfish, was 1.4 megatons, detonated at an altitude of 250 miles. Again these tests were utilized to get effects information on basic physics phenomena at high altitude and to understand better the communications and radar blackout phenomena.

We have thus clearly acquired a great deal of nuclear weapons effects information at high altitude. This information is of great benefit to devising systems for defense against ballistic missiles. It is also of great benefit to the designing of instruments to detect and identify nuclear explosions that are detonated at high altitude or in outer space.

Most of the information on our high altitude tests and on the Soviet high altitude tests is classified.

This information is, however, available to all Senators who have a need to know and who have appropriate clearance.

I do not understand the constantly repeated assertion that we need to wipe out the treaty and fail to vote for it because, somehow, we need to examine more carefully and find out what happens in high altitude tests. I repeat, we have done more than the Russians have done in that field.

The fear has been expressed that the Russians might try to preempt retaliation by this strategy.

The blackout is not instantaneous. If our communications start getting fuzzy in a way peculiar to an atomic blast, we will know a violation of the test ban treaty has occurred or an attack has begun. And we will know who is responsible. Our retaliatory forces will be alerted, and I expect the "hot line" phone between the White House and the Kremlin will be ringing.

In the absence of a limited treaty, this country might hesitate before responding because of the belief that the incident merely reflected a Russian high altitude test. In the presence of the treaty, it must then be either a violation of the agreement or a preemptory act of war.

Among the chief witnesses who have expressed strong support for the treaty are Dr. Herbert York, former Director of Research and Engineering in the Defense Department under President Eisenhower; Dr. Harold Brown, who presently occupies that position; Secretary of the Air Force, Eugene Zuckert; and John A. McCone, Director of the Central Intelligence Agency. The interesting aspect of this is that each of these men not only now has, or has had, direct responsibilities and authority connected with security matters, but has had long experience dealing with atomic energy.

Dr. York is a former director of the Livermore Radiation Laboratory, which is one of the chief centers of nuclear weapons development. Dr. Brown also served as director of Livermore Radiation Laboratory. Eugene Zuckert is a former Atomic Energy Commission commissioner, with deep knowledge in military applications; and John McCone is a former distinguished chairman of the AEC and, of course, has the best and most current knowledge of Russian weapons capabilities.

Surely these men who have knowledge of both military operational requirements and nuclear weapons could not be advocates of the treaty unless they were confident its ratification would not endanger this country.

Mr. President, I have attempted to set forth some of the scientific and technical issues involved in the question of ratification of the limited test ban agreement. The weapons we are discussing are not conventional weapons, the effects of which our minds rather easily can comprehend. They are unconventional weapons whose destructive power has sown fear throughout the world. Many of those who most precisely understand nuclear weapons because they have created them are awed—and frankly, frightened—by the enormity of this force. This feeling was expressed simply, but eloquently, by Dr. Bradbury of Los Alamos Scientific Laboratory, to the Foreign Relations Committee when he said:

I must confess to a horror of a possible nuclear war, perhaps because I have been in this business for a long time. I was in this business at the time of Hiroshima and Nagasaki. I saw those pictures. I never quite lost the feeling of incredible concern that one might some day see another city like these.

That expression is not voiced of timidity, Mr. President. It is the voice of concern for one's country and all mankind. I share that concern. These men who have helped design bombs know the horror the bombs can create. The great bulk of bombs in our stockpile were designed at Los Alamos, and therefore I would close my talk with a resolution from the American Federation of Scientists chapter at Los Alamos Scientific Laboratory which declares its support of the treaty. I ask unanimous consent that its resolution be inserted at the end of my remarks.

The PRESIDING OFFICER. Without objection, it is so ordered.

(See exhibit 1.)

Mr. ANDERSON. Therefore, Mr. President, I shall support the treaty, based, I hope, upon sufficient information on atomic energy so that I have some competence in its propriety. I believe I attended the first witnessing by civilians of the bomb test in 1951. I was a member of the Joint Committee on Atomic Energy then. There was great concern by all as to how it would work out, how it might be done. I have followed the information from all the tests from that date on. I think I have examined every set of figures produced by the Atomic Energy Commission on these tests. After 12 years of experience, I think I can say I believe this treaty can be safely ratified.

EXHIBIT 1

The Los Alamos Chapter of the Federation of American Scientists welcomes the nuclear test ban treaty now before the U.S. Senate as an initial contribution to the control of an irrational arms race. The treaty raises the hope that a peaceful world can be achieved by a sequence of mutually beneficial and attainable objectives.

From the scientific testimony presented at a series of hearings before the Joint Committee on Atomic Energy in March 1963, it is evident that violations of this treaty leading to meaningful nuclear weapon improvements have little chance of escaping detection.

With minimal threat to our security the treaty therefore may achieve numerous tangible and intangible advantages for the United States and the world.

The treaty offers the opportunity for demonstration of the international cooperation needed to open further avenues to a peaceful world.

Its sharp curtailment of atmospheric testing correspondingly limits the radioactive contamination of our environment.

Adherence to it by numerous nations which now are, or which shortly will be, capable of nuclear weapons development is evidence of its effect in preventing the global spread of such weapons.

It formally recognizes the idea that world peace can be best constructed by the successful implementation of limited practical steps—a view long advocated in American foreign policy.

This treaty deserves the wholehearted support of the American people.

The Los Alamos Chapter of the Federation of American Scientists has among its members scientists with a wide range of experience, including the design and testing of nuclear weapons. One of its principal aims is the encouragement of responsible discussion of the interaction of science and con-